

REMARKS

As requested by the Examiner, the title of the application has been amended. No new matter has been added.

Claim 6 has been rejected under 35 USC 103(a) as being unpatentable over Kondo et al in view of Uzoh et al, Maenosono and WO 01/49898 (WO '898). Claim 5 has been rejected under 35 USC 103(a) as being unpatentable over Kondo in view of Uzoh, Maenosono and WO '898 and further in view of Yoshida et al and Verbunt. Applicants respectfully traverse this ground of rejection and urge reconsideration in light of the following comments.

As discussed previously, the present invention is directed to a method of electroless copper plating which comprises the steps of preparing a pretreatment agent by reacting or mixing a noble metal compound and a silane coupling agent having a functional group with metal-capturing capability, pretreating a mirror surface having a surface roughness of less than 10nm with a pretreatment agent prior to electroless copper plating, performing electroless copper plating on the pretreated mirror surface with an electroless copper plating solution comprising a first reducing agent, hypophosphorus acid or a hypophosphite as a second reducing agent and a stabilizer for inhibiting copper deposition and forming a thin film having a thickness of no more than 500nm on the pretreated mirror surface by the electroless copper plating.

The present invention utilizes an electroless copper plating solution which enables a uniform plating at a lower temperature to be provided on a mirror surface, such as a semiconductor wafer, which conventionally are difficult to plate.

As explained in the previous Response, the instant invention is based on the discovery that when a first reducing agent and a second reducing agent comprising hypophosphorus acid or a hypophosphite are used simultaneously in an

electroless copper plating solution, the initial plating activity utilizing a metal catalyst is higher and when a stabilizer for inhibiting copper deposition is also used at the same time, excessive deposition reactions are prevented and a uniform plating is achieved at lower temperatures on a mirror surface having a surface roughness of less than 10nm. The present invention is particularly effective in producing a thin film having a thickness of no more than 500nm. It is respectfully submitted that the presently claimed invention clearly is patentably distinguishable over the references cited by the Examiner.

The Kondo et al reference is directed to an electroless copper plating solution which contains a source of a copper ion, trialkanolmonoamine as a complexing agent for the copper ion and as an accelerator and can also contain a reducing agent, pH adjuster and a stabilizer. The reducing agent is disclosed as not being particularly limited and formaldehyde and derivatives thereof are disclosed as being most suitable.

Column 13 of this reference discloses that although formaldehyde is preferred as a reducing agent, due to the toxicity of formaldehyde, it is better if the amount of formaldehyde is reduced and other reducing agents are jointly used therewith. As a second reducing agent being used with the formaldehyde, sodium hypophosphate is disclosed. This reference further states that sodium hypophosphate is the most generally used reducing agent, has no reducing activity on the surface of copper and thus was not used in electroless copper plating except as an activator. Since Figures 9 and 10 of this reference show that the plating rate for formaldehyde combined with sodium hypophosphate is almost the same as that of formaldehyde alone, it is added only to reduce the amount of formaldehyde contained in the plating solution. Therefore, there is nothing in this reference which suggests that any other advantage, other than potentially reducing toxicity, would be gained by combining sodium hypophosphate with formaldehyde.

It is also to be pointed out that the Kondo et al reference does not disclose that the substrate being plated has a mirror surface with a very small surface roughness. This reference discloses that the surface of the substrate to be treated is generally cleaned and mechanically roughened. As such, it is expected that the surface of the substrate is not a mirror surface and there would not be any expectation that the method disclosed there would be suitable for a substrate with a mirror surface.

In the outstanding Office Action, the Examiner has stated that Kondo explains "From FIG. 9, it is certain that sodium hypophosphite, although it does not act alone, effectively accelerates the plating reaction if used in combination with formalin", and that Figure 9 further shows that the deposition rate is significantly and measurably higher when sodium hypophosphite is added when used with a triethanolamine complexing agent. However, this reference only discloses that sodium hypophosphite accelerates the plating reaction if used in combination with formalin and this accelerated reaction means an accelerated deposition rate as shown in Figure 9. In contrast thereto, the present invention is not concerned with the deposition rate of any kind. One of the objects of the present invention is to provide an electroless copper plating solution which enables the uniform plating at low temperatures to be obtained for a mirrored surface substrate such as a semiconductor wafer, on which a plating reaction is typically difficult to obtain. As will be explained below, the effect of uniform plating at lower temperatures is shown in the Examples contained in the present specification. The secondary references cited by the Examiner must suggest that such an effect would be obtained in order to negate the patentability of the presently claimed invention. It is respectfully submitted that the secondary references contain no such disclosure.

Uzoh et al is directed to a method for forming conductor structures on a semiconductor wafer which requires the steps

of depositing a seed layer having a substantially consistent thickness over a barrier layer that covers the features in the field regions, electrodepositing a planar copper layer on the seed layer and subsequently electro-etching it until a thinned seed layer remains over the field regions. When another layer of planar copper is deposited on the remaining copper in the features and on the thinned seed layer on the field regions, the structure minimizes stress-related defects in the features which occur during a following annealing process.

Utoh et al has been cited by the Examiner as teaching that it is well known when providing copper electroless plating that it is desirable to overplate substrates formed from silicon wafers and that the copper plating can be from 2 to 250nm for the seed layer. However, the primary Kondo et al reference is concerned with articles or substrates having a chemically roughened surface, which excludes silicone wafers therefrom. Therefore, Applicants respectfully submit that one of ordinary skill in the art would not attempt to extend the teachings contained in Utoh et al to the Kondo et al reference.

Maenosono discloses a support for a flexible magnetic recording medium made of a polyimide film obtained by coating a solution of a solvent-soluble polyimide resin on a solid substrate having a smooth surface, removing the solvent and then peeling apart a coated film from the substrate. This reference has been cited by the Examiner as disclosing that silicon wafers and other substrates with an average surface roughness of 10nm or less, preferably 5nm or less, are commonly coated by electrochemical deposition methods. However, the present invention is concerned with electroless plating and not electrochemical deposition as disclosed in Maenosono.

Maenosono additionally states in paragraph [0030] "Such a thin film is preferably made of a material that the resistance (adhesion) during peeling apart the polyimide film after forming the polyimide film is low." This suggests that the

deposited thin layer of Maenosono is not required to adhere to the substrate, which is opposite to that of the present invention where the aim is for the plated thin film to stably bond to the surface of the substrate. The disclosure in Maenosono that a thin film of another material may be formed on a substrate having a high flatness and center line surface roughness of no more than 10nm by electrochemical deposition would not provide the motivation to one of ordinary skill in the art to combine Maenosono and Kondo et al since there would be no expectation that Kondo et al's solution, which is designed to be used with a conventionally roughened substrate surface, could also be used with substrates having a mirror surface as required by the Maenosono reference. Additionally, the Maenosono reference is directed to electrochemical deposition and not electroless plating for forming the thin film on the surface of the substrate and then subsequently removing the deposited thin layer. As such, Applicants respectfully submit that only hindsight provided by the present disclosure is motivating the Examiner to combine Maenosono et al with Kondo and Uzoh et al and even then a showing of prima facie obviousness is not made by the combination of these three references.

WO '898 is directed to a metal plating method which requires the admixing or reacting of a noble metal compound as a catalyst with a silane coupling agent containing a functional group having the capability of capturing a metal to prepare a pre-treating agent, subjecting an article to be treated to the surface treatment with the pre-treating agent and then subjecting the pre-treated article to electroless plating. This reference also discloses that the method can be used for an article having a mirror surface, such as a semiconductor wafer.

In the outstanding Office Action, the Examiner states that WO '898 discloses a desirable pretreatment agent for providing palladium on a surface with a mirror finish, such as a semiconductor wafer, by using a pretreatment agent with a

noble metal compound reacted or mixed in advance with a silane coupling agent having a functional group with a metal capturing capability. However, as discussed above, since Kondo et al is concerned with plating an article having a roughened surface, WO '898 does not cure the deficiencies with respect to combining Kondo et al, Uzoh et al and Maenosono and, therefore, this combination of references does not even present a showing of prima facie obviousness under 35 USC 103(a).

Yoshida et al has been cited by the Examiner as teaching that when providing copper electroless plating solutions, it is known to exchange formalin for glyoxylic acid as a reducing agent to provide a less problematic material and that glyoxylic acid has a structure similar to formalin and is believed to have an oxidation reaction mechanism similar to formalin, although the plating reaction proceeds more slowly than with formalin.

Verbunt has been cited by the Examiner as teaching that when providing copper electroless plating solutions, it is well known to provide hypophosphite in the form of sodium hypophosphite or to provide the hypophosphite from hypophosphorus acid.

Verbunt and Yoshida et al do not provide the teachings missing in Kondo et al, Uzoh et al, Maenosono and WO '898. Therefore, this combination of references does not provide a showing of prima facie obviousness under 35 USC 103(a).

In comparison with the instant invention, the Kondo et al reference does not teach the use of a noble metal/silane pretreatment agent before electroless plating. The application of the noble metal/silane pretreatment agent having a functional group with a metal-capturing capability to a mirrored surface, such as a semiconductor wafer, is considered to be an essential part of the present invention. It is theorized that the application of a noble metal/silane pretreatment agent having a functional group with a metal-capturing capability allows a palladium catalyst to be

uniformly and firmly adhered to the mirror surface and, when the pretreated mirror surface is treated with the plating solution of the present invention, the second reducing agent (phosphinic acid), which has a higher activity, acts on the cupric ions, initiates uniform copper deposition in a first phase and then the additionally deposited copper activates the first reducing agent (glyoxylic acid), thereby improving the copper uniformity. It is through this mechanism that a thin, adhesive and uniform copper film can be formed on a mirrored surface such as a semiconductor wafer.

On pages 10-14 of the present specification, seven Examples of the present invention and three Comparative Examples are shown. The Comparative Examples all fall within the scope of the prior art cited by the Examiner. As shown in the Comparative Examples, when electroless plating was conducted at 60°C, a uniform plating could not be achieved on the surface of the silicon wafer. In contrast thereto, when the plating solution of the present invention was used at 60°C, a uniform plating was provided on the silicon wafer surface. This is clearly unexpected in light of the prior art cited by the Examiner and establishes the patentability of the presently claimed invention thereover.

The Examiner is respectfully requested to reconsider the present application and to pass it to issue.

Respectfully submitted,


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